Stop 'N Go Light in a Tornado

Tornado Tube® Activities

Introduction

The "Blue Bottle" experiment, which uses the indicator methylene blue, has long been used in chemistry to demonstrate oxidation–reduction and kinetics. The solution changes from colorless to blue as oxygen is added with shaking. If indigo carmine is used as an indicator in place of methylene blue, the solution changes from yellow to red–orange to green with shaking, forming a "Stop-'N-Go Light" effect. An interesting variation on this "Stop-'N-Go Light" is to use a Tornado Tube to join two, 2-L soda bottles. When one of the bottles is filled with solution and swirled, the solution first turns yellow, then red–orange, and then green as it falls into the second bottle.

Concepts

- Oxidation–Reduction
- Indicators

Materials

Dextrose, 12 g
Indigo carmine, 1% solution
Sodium hydroxide, 20 g
Water, distilled or deionized
Plastic soda bottles, 2-L, 2
Tornado Tube®

Safety Precautions

Sodium hydroxide, a strong base, is a corrosive liquid; skin burns are possible. Much heat evolves when added to water. Take extra caution as the 2-L bottles may leak or the cap may crack. Indigo carmine solution is slightly toxic by ingestion and is a body tissue irritant. Avoid eye and body tissue contact with all chemicals. Use only plastic bottles, not glass. Wear chemical splash goggles, c hemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

Solution A — 1.0 M NaOH solution [20 g of NaOH (or 28 g of KOH) per 500 mL of distilled or deionized water].

Solution B — 0.13 M dextrose solution [12 g of dextrose per 500 mL of distilled or deionized water].

Solution C — 1% indigo carmine solution [1 g of indigo carmine per 100 mL distilled or deionized water. Prepare this solution fresh as it has a poor shelf life].

Procedure

1. Fill one plastic 2-L soda bottle with 500 mL of Solution A and 500 mL of Solution B. Add 50 mL of Solution C.
2. Allow the mixture to stand until the solution color changes from green to yellow (approximately five minutes).
3. Attach a Tornado Tube to the soda bottle with the solution mixture. Connect another plastic 2-L soda bottle to the other end of the Tornado Tube. A more intense green color can be obtained by filling the empty bottle with oxygen gas.
4. Invert the bottles so that the yellow solution is on top. Give the bottles a swirl to create a vortex. Observe the color changes as the liquid falls into the lower bottle.
5. If air (oxygen) is added every few times, this demonstration may be repeated many times. Simply unscrew the bottles to allow fresh air to enter.

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Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures govering the disposal of laboratory waste. Flush the final solution down the drain with excess water according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

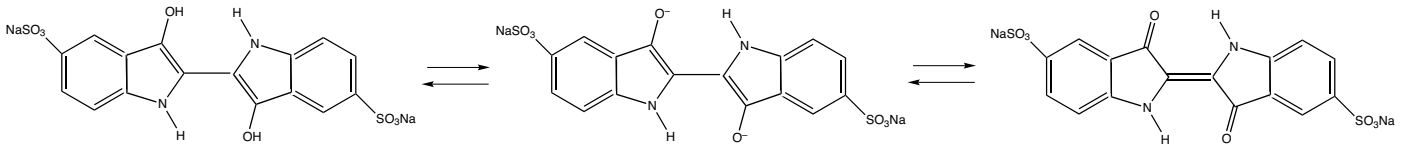
This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter, motions and forces
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions, motions and forces

Discussion

The Stop–'N–Go Light solution will be green initially. Allow the solution to sit undisturbed until it becomes a bright amber (yellow). This may take as long as 10 minutes. If the solution is not bright amber, more indigo carmine solution may be needed. Show the amber solution to the class and then swirl the tornado tube setup gently. The first swirl of the bottles will dissolve enough oxygen to cause the indigo carmine to change from yellow to red. As the liquid falls through the tornado tube hole into the lower bottle, more oxygen dissolves and a green color appears. After standing for a few minutes, reduction occurs and the system will return to yellow. The Stop-'N-Go Light solution will repeat this yellow to red to green cycle for hours depending on how often it is shaken and how much oxygen is reintroduced by opening the bottle. The colors will become less vivid with time. The indigo carmine solution has a limited shelf life (6 to 12 months) and should be royal blue in color. If it is not blue, the solution needs to be prepared fresh in order for the demonstration to work.

An alkaline dextrose solution is shaken in the presence of oxygen and indigo carmine. Indigo carmine can be reduced by the alkaline sugar and oxidized by the oxygen in the bottle. When the reduced form of indigo carmine (amber color) is agitated, it becomes oxidized to the green color. Shakhashiri proposes the middle structure below as the red intermediate. As the solion containing the oxidized forms is allowed to sit, most of the available dissolved oxygen is used up and the indigo carmine is slowly reduced back to the reduced form (amber color). After about 10 or 15 cycles, when all of the oxygen in the flask has been used up, the redox reaction will cease. Remove the stopper to introduce more air and repeat the process. An outline of the reaction mechanism for indigo carmine indicator is as follows:



reduced form (amber) | intermediate (red) | oxidized form (green)

Acknowledgments

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Reference

Shakhashiri, B. Z. *Chemical Demonstrations: A Handbook for Teachers in Chemistry;* University of Wisconsin, Madison; Vol. 2, pp 145–146.

Materials for *Stop 'N Go Light in a Tornado* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP1930	Tornado Tube
D0005	Dextrose, 500 g
I0047	Indigo carmine, 5 g
S0279	Sodium hydroxide, 500 g
AP2083	Stop-'N-Go Light Demonstration Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.